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A STUDY OF SPOTTED OWL DEMOGRAPHICS IN
THE SIERRA NATIONAL FOREST AND SEQUOIA
AND KINGS CANYON NATIONAL PARKS

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A STUDY OF SPOTTED OWL DEMOGRAPHICS IN THE SIERRA NATIONAL
FOREST AND SEQUOIA AND KINGS CANYON NATIONAL PARKS

by

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INTRODUCTION

This report summarizes key activities and preliminary results of demographic studies of California spotted owls (*Strix occidentalis occidentalis*) in the Sierra National Forest and the Sequoia and Kings Canyon National Parks for 1998. Demographic studies were initiated in March of 1990. Information collected will allow comparisons between spotted owl demographics in a managed National Forest and protected forests of the National Park. In 1994 an additional study area was initiated in Sierra National Forest to provide complete coverage of the Kings River Sustainable Forest Ecosystem Project Area. Results from all study areas are provided in this report. All tables and figures have been updated to reflect the current analysis of data for all years (1990-1998) and those tables and figures supersede all previous annual reports. Data contained herein are preliminary and permission to publish any of the contents of the report is therefore withheld pending specific authorization.

OBJECTIVES

1. Estimate densities of spotted owls and occupancy status of owl territories in the designated study areas.
2. Estimate vital rates (reproduction, mortality) by age class.
3. Assess site fidelity among individual spotted owls.
4. Estimate the number of missing and replaced spotted owls.
5. Quantify the distribution of habitats within the study areas.
6. Characterize diets of spotted owls from regurgitated pellets, and compare diets of breeding and nonbreeding pairs during the breeding period (1 March to 30 September).

STUDY AREAS

Boundaries of study areas were delineated on major topographic features such as ridges, drainages (major rivers), and administrative boundaries (e.g., Sequoia and Kings Canyon National Parks boundaries). The Sierra National Forest study area (SNF) covers 161 mi², the New Sierra study area (NS) covers 103 mi² and the Sequoia and Kings Canyon National Parks study area (SNP) covers 130 mi² (Fig. 1). Three vegetation zones are found in all study areas, oak woodland (1,000 to 4,000 feet), mid-elevation coniferous forest (4,000 to 8,000 feet) and high elevation coniferous forest (8,000 to 9,600 feet). A detailed description of these vegetation types and the area they occupy for the SNF and SNP can be found in the 1990 annual report (Verner et al. 1990), and for NS can be found in the 1993-1994 annual report (Steger et al. 1995).

METHODS

We attempted to locate, capture, and color band all spotted owls within the three study areas. Spotted owls were located by night and day calling surveys using vocal imitations of spotted owls to elicit responses (Forsman 1983). Survey methods included point surveys, leap-frog road surveys, and walking cruises. All study areas were subdivided into sites that could usually be completely surveyed during a workday.

The protocols for surveying, and for determining social, nesting, and reproductive status can be found in Verner et al. (1990). In general, we attempted to apply equal survey effort over years and study areas. Survey effectiveness may have been influenced by inclement weather conditions, such as high winds or steady rain, and water noise when surveying drainages. If budgets decline, then a priority system of calling will be initiated in

an effort to obtain full coverage (six surveys) in sites where owl pairs were detected in previous years. Mixed conifer sites will have the highest priority, low-elevation sites will receive only three surveys unless an owl is detected. Sites above 8,000 ft (2,438 m) that had no history of territorial owls may not be surveyed.

Adult and subadult survival rate, as well as juvenile survival rate and fecundity, were used to estimate the population growth rate (λ). Adult and subadult survival rate (S) included both males and females and included owls that may temporarily occupy a territory. Jolly-Seber (J-S) survival estimates were calculated with the J-S capture-recapture model for open populations, allowing for losses and gains to the population between sampling periods. A sampling period was defined as one field season (1 March-30 September). Assumptions of the J-S model were that all individuals in the population have equal survival and capture probabilities and emigration was permanent. The juvenile survival rate (S_o) was estimated at 0.328, the current estimate for a closed population of spotted owls in southern California (LaHaye et al. 1997). Fecundity (b) equaled the number of female fledglings produced divided by the number of females checked for reproduction. Assuming a 50/50 sex ratio of juveniles, fecundity was calculated by halving the mean number of young fledged per pair. The estimate of λ allowed testing of the hypothesis that a population was significantly increasing ($\lambda > 1$) or decreasing ($\lambda < 1$). The appropriate test statistics followed a Z-distribution.

RESULTS

SURVEY

Surveys began in all study areas in the first week of March and ended on 30 September. The changes in survey effort that occurred in 1997 were continued in 1998. Survey effort in 1998 was hampered by frequent late season storms driven by the El Niño effect, resulting in only partial coverage in some sites that usually receive full coverage.

DETECTION AND CAPTURE

The SNF declined to 50 adult and subadult owls (a loss of 7 from 1997) (Table 1a). Twenty pairs were detected in 1998 and two juveniles were produced. Pair numbers declined while reproduction remained similar to the 1995-1997 seasons. For the nine years of the study, the SNF has averaged 28.3 pairs/year, producing an average of 15 juveniles/year, or 0.530 juveniles per pair per year. The adult-subadult ratio was 89:11, the same as 1997 (Table 2a). In 1998, five owls (2 males [1 adult, 1 subadult] and 3 females [1 adult, 1 subadult, 1 unknown age]) were captured. The female subadult captured in 1998 was from the 1997 cohort. It was recaptured approximately 7 miles from its natal area. This juvenile owl was tracked with radio telemetry in the fall of 1997 until the transmitter fell off. During that time the juvenile moved approximately 30 miles into the SNP. Sometime after losing its transmitter in SNP, the juvenile returned to the SNF and paired with a territorial male. All juveniles that were found in the study area in 1998 were captured and banded, 1 juvenile was fitted with a radio transmitter for a study of survival rate and dispersal distance.

For SNP, the number of owls detected declined from 63 in 1997 to 58 in 1998. Twenty-four pairs were detected in 1998 and 9 juveniles fledged (Table 1b). The average number of juveniles fledging per year is 13.2 from an average of 27.5 pairs of owls, or 0.481 juveniles per pair per year. The adult-subadult ratio was 94:6 on the SNP in 1998; three female owls were captured and banded (1 adult, 2 subadults). All juveniles found were captured and banded, and two of these were fitted with radio transmitters.

On the NS study area, 24 owls were detected: 10 pairs, two single females, and one male and female present (Table 1c). Three juveniles fledged in 1998. NS averaged 3.8 juveniles from 12.8 pairs of owls, or 0.297 juveniles per pair per year for the 5 years of study.

Two new owls, 1 male subadult and 1 female adult were captured and banded. The adult-subadult ratio was 95:5, similar to the 1996 and 1997 ratios (Table 2c). All juveniles detected were captured and banded; one juvenile was fitted with a radio transmitter.

DENSITY

Densities of owls per square mile for 1998 were 0.313 on SNF, 0.446 on SNP, and 0.243 on NS (Table 3). The mean densities of owls for the nine years of study were 0.440 on SNF and 0.498 on SNP. The five-year average for the NS study area was 0.287.

MISSING OWLS, REPLACEMENTS, AND MOVEMENTS

Numbers of banded owls missing on the SNF varied substantially from 1990 through 1998 (Tables 4a-4h). In 1997-1998 there were 45 banded owls with confirmed status: 34 owls were present, 11 owls were confirmed missing, 10 were replaced and three moved to a new site within the study area. The 1998 empirical relocation rate, or the number of banded owls relocated from the previous year was 76%. The average, annual relocation rate for the time period of 1990-1998 was 80%.

Missing, replacement, and movement data for the NS are reported in tables 5a-5d. In 1997-1998 there were 20 banded owls of which 16 were relocated, four were missing, and one replacement was found.

Numbers of banded owls missing on the SNP varied substantially from 1990 through 1998 (Tables 6a-6h). In 1997-1998 there were 49 banded owls with confirmed status: 45 owls were present, four were missing, four were replaced, and three moved within the study area. The 1998 empirical relocation rate was 92%. The average relocation rate for the time period of 1990-1998 was 85.6%.

REPRODUCTION AND NESTING ATTEMPTS

Nesting attempts increased in the southern Sierra Nevada in 1998 but total reproduction was dampened by the El Niño effect during the spring and early summer of 1998. In SNF we checked 19 pairs and found 11 nesting (58%) but only 2 of 20 pairs (10%) reproduced, fledging 2 young (Tables 7, 8, 9, 10). The mean number of young fledged per pair checked for reproduction was 0.10. In the SNP we found 8 of 20 pairs nesting (40%) and 6 of 22 pairs reproductive (27%), fledging 9 young. The mean number of young fledged per pair checked for reproduction was 0.41. On the NS we found 1 of 3 pairs nesting (33%), and 2 of 10 pairs reproductive (20%), fledging 3 young for a mean number of young fledged per pair checked for reproduction of 0.30.

A total of 289 fledglings have been recorded over the 9 years of the study, 140 in SNF, 128 in SNP, and 21 in NS and a total of 258 (89%) of these young have been banded with cohort bands. One returning cohort was captured in 1998. The sex ratio determined from blood samples for 1998 was 5/8 (male/female) for a total of 122 juveniles from 1993 to 1998 with a ratio of 72/50 (male/female) which does not differ significantly from a 1/1 ratio.

Reproduction has varied substantially among years but differed little between study areas. In both the SNF and SNP, the proportion of pairs fledging young was >40% in 4 years (1990, 1992, 1993, and 1994) and <40% in 5 years (1991, 1995, 1996, 1997, and 1998).

POPULATION TREND

Preliminary estimates of demographic parameters and rates of population change (λ) were 0.90 for the SNF, 0.89 for the SNF and NS combined, and 0.94 for the SNP (table 11). Fecundity (b) declined from 1997 due to poor reproduction on all study areas. For 1990-1998 we found that the fecundity rate for SNF was 0.309, SNF and NS combined was 0.277, and SNP was 0.275. Adult and subadult survival rates were 0.807 for SNF, 0.808 for

SNF and NS combined and 0.858 for the SNP. The decline in fecundity and survival rate caused lambda values to drop from previous years' calculations, especially on the Sierra Forest.

DISCUSSION

In 1998 owl numbers declined on all our study areas. The Sierra Forest population has dropped 39% from the peak in 1994 and the Sequoia Study area has dropped 28% from the 1995 peak. The drop in owl numbers may be attributable to poor reproduction for the last 3 years, resulting in fewer subadults to occupy open territories. This is supported by a lower than average ratio of subadults in the 1997 and 1998 populations. In 1998 we again recorded a year of poor reproduction, with 14 juveniles produced from the 54 pairs checked on all our study areas. On the SNF we checked 10 pair sites for nesting prior to May 15, nine of which were nesting. After mid-May we found few nesting owls and when we rechecked the 9 nesting pairs for reproduction only 1 pair fledged young. We suspect that the continual rain events from El Niño interfered with nesting in the southern Sierra Nevada. The combination of four years (1995-1998) of poor reproduction in the southern Sierra Nevada leads us to speculate that owl numbers will remain low or decline until another pulse in reproduction occurs, similar to that in 1992. It is important to remember that the decline in owl numbers has occurred on both the Sierra and Sequoia study areas and that broad-scale changes in population numbers may be resulting from shifts in prey abundance, changes in regional weather patterns, or broad-scale land management practices.

Our calculation of the rate of population change (lambda) from 1988-1998 suggests that the owl population is declining at approximately 10% for SNF and 6% for SNP per year. The calculations for 1997 indicated that λ remained approximately the same as the 1996 estimate. In 1998 we observed a 3% decline in the rate of population change on the Sierra study area and 1% decline on the Sequoia study area. Although some of this decline may be a result of poor monitoring conditions caused by El Niño, we feel that the owl numbers are currently declining. The difference between the SNF and SNP may be explained by the difference in relocation rate of banded owls. Owl survival rates over the life of the study were 5% lower on SNF than SNP. The relocation rate is used to determine subadult and adult survival rates in the λ calculation, and λ is most sensitive to this value (Noon et al. 1992).

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TABLE 1a. Summary of social status of adult and subadult California spotted owls on the SNF.

SOCIAL STATUS	1990	1991	1992	1993	1994	1995	1996	1997	1998
Pair	31	27	32	33	34	27	26	25	20
Single male	0	2	1	4	4	3	1	3	2
Single female	0	0	1	1	0	1	1	0	0
Male & female present	5	0	1	1	1	2	2	0	1
Male present	9	10	1	4	8	5	4	3	4
Female present	4	3	3	2	0	3	5	0	2
Unknown present				1	2	0	1	1	0
Total Number of Owls	85	69	72	80	84	70	68	57	50
Juveniles	22	6	52	23	20	1	4	8	2
Juveniles detected after July 15		1	1						
Total Juveniles	22	7	53	23	20	1	4	8	2

TABLE 1b. Summary of social status of adult and subadult California spotted owls on the SNP.

SOCIAL STATUS	1990	1991	1992	1993	1994	1995	1996	1997	1998
Pair	22	23	27	28	34	33	28	29	24
Single male	0	0	0	0	0	0	0	0	0
Single female	0	1	0	0	0	1	2	1	0
Male & female present	2	5	0	2	0	2	0	0	0
Male present	5	1	5	4	4	6	5	1	6
Female present	1	0	0	2	2	2	0	3	4
Unknown present	0	2	1	1	0	1	3	0	0
Female replaced					1				
Total Number of Owls	54	60	60	67	75	80	66	63	58
Juveniles	12	1	43	15	22	3	3	11	9
Juveniles detected after July 15	9								
Total Juveniles	21	1	43	15	22	3	3	11	9

TABLE 1c. Summary of social status of adult and subadult California spotted owls on the NS.

SOCIAL STATUS	1994	1995	1996	1997	1998
Pair	15	14	13	12	10
Single male	0	0	0	0	0
Single female	1	1	1	1	2
Male & female present	0	0	0	0	1
Male present	3	1	1	0	0
Female present	2	1	0	1	0
Unknown present	1	2	0	0	0
Total Number of Owls	37	33	28	26	24
Juveniles	9	1	2	4	3
Juveniles detected after July 15	2				
Total Juveniles	11	1	2	4	3

Table 2a. Sex and age class distribution of California spotted owls identified to age class on the SNF.

Sex	Age Class	1990		1991		1992		1993		1994		1995		1996		1997		1998	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Male	Adult	25	81	24	80	27	87	26	72	22	60	22	79	25	86	25	93	23	96
	Subadult	6	19	6	20	4	13	10	28	15	40	6	21	4	14	2	7	1	4
	Combined	31		30		31		36		37		28		29		27		24	
Female	Adult	22	88	28	100.0	30	97	30	91	28	85	26	90	22	73	21	84	17	81
	Subadult	3	12	0	0.0	1	3	3	9	5	15	3	10	8	27	4	16	4	19
	Combined	25		28		31		33		33		29		30		25		21	
Both	Adult	47	84	52	90	57	92	56	80	50	71	48	84	47	80	46	89	40	89
	Subadult	9	16	6	10	5	8	14	20	20	29	9	16	12	20	6	11	5	11
	Combined	56		58		62		70		70		57		59		52		45	

Table 2b. Sex and age class distribution of California spotted owls identified to age class on the SNP.

Sex	Age Class	1990		1991		1992		1993		1994		1995		1996		1997		1998	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Male	Adult	16	94	19	91	25	96	27	93	22	65	28	82	27	93	26	100	25	96
	Subadult	1	6	2	9	1	4	2	7	12	35	6	18	2	7	0	0.0	1	4
	Combined	17		21		26		29		34		34		29		26		26	
Female	Adult	11	85	18	86	25	96	25	89	28	88	33	97	29	97	31	100	24	92
	Subadult	2	15	3	14	1	4	3	11	4	12	2	3	1	3	0	0.0	2	8
	Combined	13		21		26		28		32		35		30		31		26	
Both	Adult	27	90	37	88	51	96	52	91	50	76	61	87	57	93	57	100	49	94
	Subadult	3	10	5	12	2	4	5	9	16	24	9	13	4	7	0	0.0	3	6
	Combined	30		42		53		57		66		70		61		57		52	

Table 2c. Sex and age class distribution of California spotted owls identified to age class on the NS.

Sex	Age Class	1994		1995		1996		1997		1998		1999		2000	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
Male	Adult	11	85	12	86	12	92	12	100	9	90				
	Subadult	2	15	2	14	1	8	0	0.0	1	10				
	Combined	13		14		13		12		10					
Female	Adult	9	75	15	94	11	100	12	92	11	100				
	Subadult	3	25	1	6	0	0	1	8	0	0				
	Combined	12		16		11		13		11					
Both	Adult	20	80	27	90	23	96	24	96	20	95				
	Subadult	5	20	3	10	1	4	1	4	1	5				
	Combined	25		30		24		25		21					

TABLE 3.

CRUDE DENSITY

Mean crude density estimates (owls per mi^2) for California Spotted Owls on the SNF, SNP, and NS . Crude density was calculated by dividing the number of owls detected by the number of square miles in each study area.

SNF (160.4 mi^2)	1990	1991	1992	1993	1994	1995	1996	1997	1998
Owls Detected	85	69	72	80	84	70	68	57	50
Crude Density mi^2	0.530	0.430	0.449	0.449	0.524	0.436	0.424	0.355	0.313

SNP (130.0 mi^2)	1990	1991	1992	1993	1994	1995	1996	1997	1998
Owls Detected	54	60	60	67	75	80	66	63	58
Crude Density mi^2	0.415	0.462	0.462	0.515	0.577	0.615	0.508	0.485	0.446

NS (103.0 mi^2)	1994	1995	1996	1997	1998
Owls Detected	37	33	28	26	24
Crude Density mi^2	0.359	0.320	0.272	0.252	0.243

TABLE 4. Relocation, missing, replacement and movement rates for only banded California spotted owls on the SNF: A (1990 to 1991), B (1991 to 1992), C (1992 to 1993), D (1993 to 1994), E (1994 to 1995), F (1995 to 1996), G (1996 to 1997), and H (1997-1998).

A.		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1990	N	%	N	%	N	%	N	%
Male	Adult	15	12	80	3	20	4	27	1	7
	Subadult	5	3	60	2	40	2	40	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	20	15	75	5	25	6	30	1	5
Female	Adult	12	11	92	1	8	1	8	1	8
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	13	12	92	1	8	1	8	1	8
Both	Adult	27	27	23	4	15	5	19	2	7
	Subadult	6	6	4	2	33	2	33	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Combined	33	27	82	6	18	7	21	2	6

B.		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1991	N	%	N	%	N	%	N	%
Male	Adult	17	15	88	2	12	2	12	1	6
	Subadult	5	4	80	1	20	1	20	2	40
	Unknown	0	-	-	-	-	-	-	-	-
	Total	22	19	86	3	14	3	14	3	14
Female	Adult	19	16	84	3	16	3	16	2	11
	Subadult	0	-	-	-	-	-	-	-	0
	Unknown	0	-	-	-	-	-	-	-	0
	Combined	19	16	84	3	16	3	16	2	11
Both	Adult	36	31	86	5	14	5	14	3	8
	Subadult	5	4	80	1	20	1	20	2	40
	Unknown	0	-	-	-	-	-	-	-	-
	Combined	41	35	85	6	15	6	15	5	12

		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1992	N	%	N	%	N	%	N	%
Male	Adult	26	21	81	5	19	5	19	0	-
	Subadult	4	3	75	1	25	1	25	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	30	24	80	6	20	6	20	0	-
Female	Adult	26	24	92	2	8	2	8	0	-
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Total	28	26	93	2	7	2	7	0	-
Both	Adult	52	45	87	7	13	7	13	0	-
	Subadult	5	4	80	1	20	1	20	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Combined	58	50	86	8	14	8	14	0	-

		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1993	N	%	N	%	N	%	N	%
Male	Adult	22	15	68	7	32	6	27	0	-
	Subadult	7	5	71	2	29	1	14	1	4
	Unknown	2	2	100	0	-	0	-	0	-
	Total	31	22	71	9	29	7	23	1	3
Female	Adult	29	24	83	5	17	4	14	1	3
	Subadult	2	2	100	0	-	0	-	0	-
	Unknown	2	2	100	0	-	0	-	0	-
	Combined	33	28	85	5	15	4	12	1	3
Both	Adult	51	39	76	12	24	10	20	1	2
	Subadult	9	7	78	2	22	1	11	1	11
	Unknown	4	4	100	0	-	0	-	0	-
	Combined	64	50	78	14	22	11	17	2	3

		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1994	N	%	N	%	N	%	N	%
Male	Adult	20	17	85	3	15	2	10	1	5
	Subadult	10	7	70	3	30	1	10	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	30	24	80	6	20	3	10	1	3
Female	Adult	27	21	78	6	22	4	15	3	11
	Subadult	4	3	75	1	25	1	25	1	25
	Unknown	1	1	100	0	-	0	-	0	-
	Combined	32	25	78	7	22	5	16	4	13
Both	Adult	47	38	81	9	19	6	13	4	9
	Subadult	14	10	71	4	29	2	14	1	7
	Unknown	1	1	100	0	-	0	-	0	-
	Combined	62	49	79	13	21	8	13	5	8

<u>F.</u>		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1995	N	%	N	%	N	%	N	%
Male	Adult	21	18	86	3	14	3	14	0	-
	Subadult	3	2	67	1	33	0	-	1	33
	Unknown	3	2	67	1	33	1	33	0	-
	Total	27	22	82	5	19	4	15	1	4
Female	Adult	25	17	68	8	32	8	32	0	-
	Subadult	3	3	100	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Total	29	21	72	8	28	8	28	-	-
Both	Adult	46	35	76	11	24	11	24	0	-
	Subadult	6	5	83	1	17	0	-	1	17
	Unknown	4	3	75	1	25	1	25	0	-
	Combined	56	43	77	13	23	12	21	1	2

<u>G.</u>		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1996	N	%	N	%	N	%	N	%
Male	Adult	23	20	87	3	13	3	13	2	9
	Subadult	3	1	33	2	67	1	33	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	26	21	81	5	19	4	15	2	8
Female	Adult	22	16	73	6	27	4	18	1	5
	Subadult	5	3	60	2	40	2	40	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Total	28	20	71	8	29	6	21	1	4
Both	Adult	45	36	80	9	20	7	16	3	7
	Subadult	8	4	50	4	50	3	37	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Combined	54	41	76	13	24	10	19	3	6

<u>H.</u>		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1997	N	%	N	%	N	%	N	%
Male	Adult	22	18	82	4	18	4	18	2	9
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	22	18	82	4	18	4	18	2	9
Female	Adult	19	12	63	7	37	6	32	1	5
	Subadult	4	4	100	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	23	16	70	7	30	6	26	1	4
Both	Adult	41	30	73	11	27	10	24	3	7
	Subadult	4	4	100	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Combined	45	34	76	11	24	10	22	3	7

TABLE 5. Relocation, missing, replacement and movement rates for only banded California spotted owls on the NS: A (1994 to 1995), B (1995 to 1996), C (1996 to 1997), and D (1997 to 1998).

A.		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1994	N	%	N	%	N	%	N	%
Male	Adult	11	9	82	2	18	1	9	0	-
	Subadult	0	-	-	-	-	-	-	-	-
	Unknown	2	2	100	0	-	0	-	0	-
	Total	13	11	85	2	15	1	8	0	-
Female	Adult	9	9	100	0	-	0	-	0	-
	Subadult	3	3	100	0	-	0	-	0	-
	Unknown	2	2	100	0	-	0	-	0	-
	Total	14	14	100	0	-	0	-	0	-
Both	Adult	20	18	90	2	10	1	5	0	-
	Subadult	3	3	100	0	-	0	-	0	-
	Unknown	4	4	100	0	-	0	-	0	-
	Combined	27	25	93	2	7	1	4	0	-

B.		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1995	N	%	N	%	N	%	N	%
Male	Adult	12	9	75	3	25	3	25	1	8
	Subadult	2	1	50	1	50	0	-	1	50
	Unknown	0	-	-	-	-	-	-	-	-
	Total	14	10	71	4	29	3	21	2	14
Female	Adult	14	12	86	2	14	1	7	1	7
	Subadult	1	0	0	1	100	0	-	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	15	12	80	3	20	1	7	1	7
Both	Adult	26	21	81	5	19	4	15	2	8
	Subadult	3	1	33	2	67	0	-	1	33
	Unknown	0	-	-	-	-	-	-	-	-
	Combined	29	22	76	7	24	4	14	3	10

<u>C.</u>		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1996	N	%	N	%	N	%	N	%
Male	Adult	10	7	70	3	30	1	10	0	-
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Total	12	9	71	3	29	1	8	0	-
Female	Adult	11	10	90	1	10	1	10	0	-
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	3	2	66	1	33	0	-	0	-
	Total	14	12	86	2	14	1	7	0	-
Both	Adult	21	17	81	4	19	2	10	0	-
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	4	3	75	1	25	0	-	0	-
	Combined	26	21	81	5	19	2	8	0	-

<u>D.</u>		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1997	N	%	N	%	N	%	N	%
Male	Adult	9	6	67	3	33	1	11	0	-
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	9	9	67	3	33	1	11	0	-
Female	Adult	11	10	90	1	10	0	-	0	-
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	11	10	90	1	10	0	-	0	-
Both	Adult	20	16	80	4	20	1	5	0	-
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Combined	20	16	80	4	20	1	5	0	-

TABLE 6. Relocation, missing, replacement and movement rates for only banded California spotted owls on the SNP: A (1990 to 1991), B (1991 to 1992), C (1992 to 1993), D (1993 to 1994), E (1994 to 1995), F (1995 to 1996), G (1996 to 1997), and H (1997 to 1998).

A.		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1990	N	%	N	%	N	%	N	%
Male	Adult	9	8	89	1	11	1	11	0	-
	Subadult	1	1	100	0	-	0	-	1	100
	Unknown	1	1	100	0	-	0	-	0	-
	Total	11	10	91	1	9	1	9	1	9
Female	Adult	7	5	71	2	29	1	14	0	-
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	3	2	67	1	33	1	33	0	-
	Total	11	8	73	3	27	2	18	0	-
Both	Adult	16	13	81	3	19	2	13	0	-
	Subadult	2	2	100	0	-	0	-	1	50
	Unknown	4	3	75	1	25	1	25	0	-
	Combined	22	18	82	4	18	3	14	1	5

B.		No	RELOCATED		MISSING		REPLACED		MOVED	
		Banded								
Sex	Age Class	1991	N	%	N	%	N	%	N	%
Male	Adult	11	8	73	3	27	2	18	0	-
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	3	3	100	0	-	0	-	0	-
	Total	15	12	80	3	20	2	13	0	-
Female	Adult	11	9	82	2	18	3	27	1	9
	Subadult	2	2	100	0	-	0	-	1	50
	Unknown	1	1	100	0	-	0	-	0	-
	Total	14	12	86	2	14	3	21	2	14
Both	Adult	22	17	77	5	23	5	23	1	5
	Subadult	3	3	100	0	-	0	-	1	33
	Unknown	4	4	100	0	-	0	-	0	-
	Combined	29	24	83	5	17	5	17	2	7

C.		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1992	N	%	N	%	N	%	N	%
Male	Adult	24	24	100	0	-	0	-	0	-
	Subadult	0	-	-	-	-	-	-	-	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	24	24	100	0	-	0	-	0	-
Female	Adult	23	20	87	3	13	3	13	0	-
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Total	25	22	88	3	12	3	12	0	-
Both	Adult	47	44	94	3	6	3	6	0	-
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Combined	49	46	94	3	6	3	6	0	-

D.		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1993	N	%	N	%	N	%	N	%
Male	Adult	26	20	77	6	23	5	19	0	-
	Subadult	2	2	100	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	1	100
	Total	29	23	70	6	21	5	17	1	3
Female	Adult	23	20	87	3	13	2	9	0	-
	Subadult	2	2	100	0	-	1	50	1	50
	Unknown	1	1	100	0	-	1	100	1	100
	Total	26	23	88	3	12	4	15	2	8
Both	Adult	49	40	82	9	18	7	14	0	-
	Subadult	4	4	100	0	-	1	25	1	25
	Unknown	2	2	100	0	-	1	50	2	100
	Total	55	46	84	9	16	9	16	3	5

E.		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1994	N	%	N	%	N	%	N	%
Male	Adult	20	17	85	3	15	3	15	0	-
	Subadult	9	8	89	1	11	0	-	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	29	25	86	4	14	3	10	0	-
Female	Adult	27	23	85	4	15	3	11	0	-
	Subadult	3	2	67	1	33	0	-	0	-
	Unknown	3	3	100	0	-	0	-	0	-
	Total	33	28	85	5	15	3	9	0	-
Both	Adult	47	40	85	7	15	6	13	0	-
	Subadult	12	10	83	2	17	0	-	0	-
	Unknown	3	3	100	0	-	0	-	0	-
	Combined	62	53	85	9	15	6	10	0	-

<u>F.</u>		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1995	N	%	N	%	N	%	N	%
Male	Adult	26	20	77	6	23	5	19	1	4
	Subadult	5	3	60	2	40	1	20	2	40
	Unknown	0	-	-	-	-	-	-	-	-
	Total	31	23	74	8	26	6	19	3	10
Female	Adult	33	27	82	6	18	1	3	1	3
	Subadult	2	1	50	1	50	0	-	0	-
	Unknown	0	-	-	-	-	-	-	-	-
	Total	35	28	80	7	20	1	3	1	3
Both	Adult	59	47	80	12	20	6	10	2	3
	Subadult	7	4	57	3	43	1	14	2	29
	Unknown	0	-	-	-	-	-	-	-	-
	Combined	66	51	77	15	23	7	11	4	6

<u>G.</u>		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1996	N	%	N	%	N	%	N	%
Male	Adult	24	20	83	4	17	4	17	1	4
	Subadult	2	2	100	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	26	22	85	4	15	4	15	1	4
Female	Adult	29	26	90	3	10	3	10	1	3
	Subadult	1	1	100	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	30	27	90	3	10	3	10	1	3
Both	Adult	53	46	87	7	13	7	13	2	4
	Subadult	3	3	100	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Combined	56	49	88	7	13	7	13	2	4

<u>H.</u>		No Banded	RELOCATED		MISSING		REPLACED		MOVED	
Sex	Age Class	1997	N	%	N	%	N	%	N	%
Male	Adult	22	22	100	0	-	0	-	0	-
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	0	0	-	0	-	0	-	0	-
	Total	22	22	100	0	-	0	-	0	-
Female	Adult	26	22	85	4	15	4	15	3	12
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Total	27	23	85	4	15	4	15	3	11
Both	Adult	48	44	92	4	8	4	8	3	6
	Subadult	0	0	-	0	-	0	-	0	-
	Unknown	1	1	100	0	-	0	-	0	-
	Combined	49	45	92	4	8	4	8	3	6

TABLE 7a. Proportion of California spotted owl pairs nesting on the SNF.

YEAR	<u>NESTING CHECKED</u> N	<u>PAIRS NESTING</u> N	<u>PROPORTION NESTING</u> Percent
1990	8	5	0.63
1991	9	6	0.67
1992	30	27	0.90
1993	33	19	0.58
1994	33	19	0.58
1995	23	6	0.26
1996	25	6	0.24
1997	25	9	0.34
1998	19	11	0.58

TABLE 7b. Proportion of California spotted owl pairs nesting on the SNP.

YEAR	<u>NESTING CHECKED</u> N	<u>PAIRS NESTING</u> N	<u>PROPORTION NESTING</u> Percent
1990	5	4	0.80
1991	11	2	0.18
1992	27	24	0.89
1993	25	15	0.60
1994	27	16	0.59
1995	31	5	0.16
1996	25	2	0.08
1997	26	6	0.23
1998	20	8	0.40

TABLE 7c. Proportion of California spotted owl pairs nesting on the NS.

<u>YEAR</u>	<u>NESTING CHECKED</u> N	<u>PAIRS NESTING</u> N	<u>PROPORTION NESTING</u> Percent
1994	11	6	0.55
1995	9	1	0.11
1996	11	1	0.09
1997	10	2	0.20
1998	3	1	0.33

TABLE 8a. Proportion of pairs of California spotted owls checked for reproduction by 15 July which fledged young on the SNF.

YEAR	Pairs Checked N	Pairs Fledging Young N	Proportion Fledging Young
1990	18	13	0.72
1991	13	5	0.38
1992	30	26	0.87
1993	33	14	0.42
1994	33	14	0.42
1995	26	1	0.04
1996	25	3	0.12
1997	25	6	0.24
1998	20	2	0.10

TABLE 8b. Proportion of pairs of California spotted owls checked for reproduction by 15 July which fledged young on the SNP.

YEAR	Pairs Checked N	Pairs Fledging Young N	Proportion Fledging Young
1990	8	7	0.88
1991	12	1	0.08
1992	27	23	0.85
1993	25	11	0.44
1994	29	14	0.48
1995	33	2	0.06
1996	27	2	0.07
1997	27	6	0.22
1998	22	6	0.27

TABLE 8c. Proportion of pairs of California spotted owls checked for reproduction by 15 July which fledged young on the NS.

YEAR	Pairs Checked N	Pairs Fledging Young N	Proportion Fledging Young
1994	11	5	0.45
1995	14	1	0.07
1996	12	1	0.08
1997	10	2	0.20
1998	10	2	0.20

TABLE 9a. Mean number of young fledged per pair of California spotted owls checked for reproduction by 15 July on the SNF.

YEAR	Pairs Checked N	Young Found N	Young Per Pair Mean
1990	18	22	1.22
1991	13	6	0.46
1992	30	52	1.73
1993	33	23	0.70
1994	33	20	0.61
1995	26	1	0.04
1996	25	4	0.16
1997	25	8	0.32
1998	20	2	0.10

Table 9b. Mean number of young fledged per pair of California spotted owls checked for reproduction by 15 July on the SNP.

YEAR	Pairs Checked N	Young Found N	Young Per Pair Mean
1990	8	12	1.50
1991	12	1	0.08
1992	27	43	1.59
1993	25	15	0.60
1994	29	22	0.76
1995	33	3	0.09
1996	27	3	0.11
1997	27	11	0.41
1998	22	9	0.41

TABLE 9c. Mean number of young fledged per pair of California spotted owls checked for reproduction by 15 July on the NS.

YEAR	Pairs Checked N	Young Found N	Young Per Pair Mean
1994	11	9	0.82
1995	14	1	0.07
1996	12	2	0.17
1997	10	4	0.40
1998	10	3	0.30

TABLE 10a. Mean number of young fledged per pair of California spotted owls that fledged young on the SNF.

YEAR	Pairs Checked N	Young Found N	Young Per Pair Mean
1990	13	22	1.69
1991	5	6	1.20
1992	26	52	2.00
1993	14	23	1.64
1994	14	20	1.43
1995	1	1	1.00
1996	3	4	1.33
1997	6	8	1.33
1998	2	2	1.00

TABLE 10b. Mean number of young fledged per pair of California spotted owls that fledged young on the SNP.

YEAR	Pairs Checked N	Young Found N	Young Per Pair Mean
1990	7	12	1.71
1991	1	1	1.00
1992	23	43	1.87
1993	11	15	1.36
1994	14	22	1.57
1995	2	3	1.50
1996	2	3	1.50
1997	6	11	1.83
1998	6	9	1.50

TABLE 10c. Mean number of young fledged per pair of California spotted owls that fledged young on the NS.

YEAR	Pairs Checked N	Young Found N	Young Per Pair Mean
1994	5	9	1.80
1995	1	1	1.00
1996	1	2	2.00
1997	2	4	2.00
1998	2	3	1.50

Table 11. Estimation of demographic parameters and rate of population change for the Sierra National Forest Study Areas, combined Sierra Study Areas, and the Sequoia and Kings Canyon National Parks Study Area

SNF	Sierra Forest	SNP
1987-1993	----	1988-1993
$S_o =$ 0.349 (Est.)		$S_o =$ 0.349 (Est.)
$S =$ 0.8433		$S =$ 0.9072
$b =$ 0.548		$b =$ 0.4227
$\text{Lambda} =$ 1.00395		$\text{Lambda} =$ 1.03634
$z =$ 0.11409		$z =$ 1.09853
1987-1994	----	1988-1994
$S_o =$ 0.349 (Est.)		$S_o =$ 0.349 (Est.)
$S =$ 0.8349		$S =$ 0.9037
$b =$ 0.484		$b =$ 0.413
$\text{Lambda} =$ 0.97896		$\text{Lambda} =$ 1.03006
$z =$ 0.69547		$z =$ 1.05136
1987-1995	1987-1995	1988-1995
$S_o =$ 0.349 (Est.)	$S_o =$ 0.349 (Est.)	$S_o =$ 0.349 (Est.)
$S =$ 0.8295	$S =$ 0.8338	$S =$ 0.8631
$b =$ 0.405	$b =$ 0.3702	$b =$ 0.3365
Lambda = 0.95258	Lambda = 0.94744	$\text{Lambda} =$ 0.96783
$z =$ 1.77871	$z =$ 2.05052	$z =$ 1.19524
P = 0.038	P = 0.02	P = 0.11
1987-1996	1987-1996	1988-1996
$S_o =$ 0.349 (Est.)	$S_o =$ 0.349 (Est.)	$S_o =$ 0.349 (Est.)
$S =$ 0.8174	$S =$ 0.8257	$S =$ 0.8575
$b =$ 0.3616	$b =$ 0.3226	$b =$ 0.2940
Lambda = 0.92850	Lambda = 0.92608	Lambda = 0.95011
$z =$ 2.91207	$z =$ 3.24961	$z =$ 2.10198
P = 0.0018	P = 0.0006	P = 0.018
1987-1997	1987-1997	1988-1997
$S_o =$ 0.328 (Est.)	$S_o =$ 0.328 (Est.)	$S_o =$ 0.328 (Est.)
$S =$ 0.8318	$S =$ 0.8356	$S =$ 0.8692
$b =$ 0.3350	$b =$ 0.3004	$b =$ 0.2827
Lambda = 0.930	Lambda = 0.9246	Lambda = 0.9537
$z =$ 3.099	$z =$ 3.632	$z =$ 2.237
P = 0.001	P = 0.0001	P = 0.013
1987-1998	1987-1998	1988-1998
$S_o =$ 0.328 (Est.)	$S_o =$ 0.328 (Est.)	$S_o =$ 0.328 (Est.)
$S =$ 0.8067	$S =$ 0.8076	$S =$ 0.8580
$b =$ 0.3094	$b =$ 0.2774	$b =$ 0.2754
Lambda = 0.898	Lambda = 0.890	Lambda = 0.940
$z =$ 4.478	$z =$ 5.203	$z =$ 2.708
P = 0.0001	P = 0.0001	P = 0.0035